Controls on Nutrient Limitation in the Coastal Ocean: Verification of Seasonal Phosphorus Limitation on the Eel River Shelf

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LONG-TERM GOAL

My long term goal is to identify the processes which control the supply of bioavailable nutrients to the coastal ocean and to evaluate controls on nutrient limitation of biological productivity in the coastal ocean. Of particular interest to me is the possibility that nutrients other than nitrogen can limit biological productivity, and understanding the conditions which favor limitation by phosphorus.

OBJECTIVES

The main objective of this work is to return to the Eel River Shelf to replicate the seasonal cruises of 1996-1997 to study the limiting nutrient dynamics of this coastal system. Results of the 1996-1997 seasonal study suggest that nutrient limitation shifted from N-limitation in spring to P-limitation in summer. I wished to document whether this is a recurring phenomenon, or whether it was an anomalous finding, but returning to the field area and replicating the earlier study.

In addition to the coupled geochemical/enzymatic approach adopted in the earlier work several new objectives were added. First, we filtered samples through both 0.40 µm and 0.20 µm filters for nutrient analyses, to document whether the dissolved organic nutrients were truly dissolved (e.g. passing through the 0.20 µm filter), or whether they were associated with bacterial cells (e.g. retained by the 0.20 µm filter). Second, we collected frozen GF/F filtered particulates for photopigment analysis in order to evaluate the algal species composition on the two cruises, to document any seasonal changes.

APPROACH

I organized and dircted two cruises to the Eel River Shelf: March and July 1998. Hydrographic surveys of the shelf were conducted, consisting of 3 to 5 shore-perpendicular transect lines, 5 to 8 stations per transect. The core of the sampling grid was between 30 and 70 m water depth, with stations every 10 meters. Deeper stations were sampled less regularly in order to characterize the deep source of potentially upwelled water. At each station a CTD (with fluorometer, transmissometer, oxygen probe, and PAR sensor) and nisken rosette were deployed, and water collected at 3 to 5 water depths per station. Typically I collected samples from approximately 100 water column depth intervals per cruise. Water samples were filtered through 0.40 µm and 0.20 µm polycarbonate filters for dissolved nutrient analyses and collection of particulates for phosphorus speciation, through GF/F filters for DOC and DON analysis, for enzymatic (alkaline phosphatase: APase) assays of the particulates, elemental (CHNS) anlysis, chl-a and photopigment determinations.

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Samples were collected from the three main rivers draining into the Eel River Shelf (the Eel, Mad, and Van Duzen Rivers) immediately after completing each cruise. Depth integrated samples were taken at USGS river gauging stations with the help of the Eureka USGS office. Samples were processed as described above for hydrographic survey samples.

Using APase as in indicator of phosphorus limitation, in conjunction with determination of nutrient inventories and biomass in the water column, the nutrient limitation status of the Eel River Shelf coastal system can be evaluated.

WORK COMPLETED

Two cruises have been successfully completed and analyses are underway.

RESULTS

Data from the CTD-fluorometer probe indicate that biomass concentrations were elevated in July relative to March, however both data sets suggest that biomass levels were lower than those observed during the 1996 cruises. This may be the result of diminished upwelling due to the El Nino conditions which prevailed during this past year. Upwelling-index data provided to me by Dr. Gregory Crawford from Humboldt State University indicate difinitively that upwelling was unfavorable during much of the spring and summer of 1998.

IMPACT/APPLICATION

Although originally intended to replicate the 1996 spring and summer cruises, due to the prevailing El Nino conditions we will have a data set which documents nutrient limitation dynamics under very different conditions than those present during the earlier cruises.

TRANSITIONS

The uncertainty which exists about which nutrient is 'the' limiting nutrient precludes construction of realistic descriptive or predictive models of coastal ocean biomass dynamics. This has important implications for academic and Naval objectives centered around prediction of biogenic particle production in the coastal ocean. A major objective of this research is to provide evidence of the importance of including 'non-traditional' nutrient pools into productivity-prediction models, and to underline the importance of explicitly documenting the identity of limiting nutrients in a given ecosystem in order to avoid assumptions which may prove unrealistic.

RELATED PROJECTS

This project has benefitted greatly from the opportunity to collaborate with scientists in the ONR-funded STRATAFORM project. In particular, Chuck Nittrouer has been exceedingly helpful in accommodating ship-time needs for carrying out the work described in this report. Nittrouer and other STRATAFORM scientists have expressed interest in the water column data which I am generating as part of this project, as it will help them to constrain the sediment delivery term for strata formation on the Eel River Shelf. In addition, I have been looking at the geochemistry of surface sediments, in particular at components derived from water column productivity, to link surface sediment parameters

which provide an indication of organic matter source and reactivity (chl-a, organic C:N:P ratios) to water column profiles of these same parameters. This will provide insight into the seasonal delivery of metabolizable organic matter to the sea bed on the Eel River Shelf. The delivery of water column biogenic particulate matter (e.g. productivity) to the sea bed has a direct effect on strata preservation, through direct sedimentation, and by increasing the supply of reactive organic matter which fuels benthic bioturbating organisms, and promotes sediment reworking and destruction of strata-boundaries.